NITRATE CONTAMINATION OF DOMESTIC WELLS IN GEORGIA

Anthony W. Tyson[1], Parshall Bush[2], Robert Perkins[3] and William Segars[4]

AUTHORS: [1]P.E., Extension Engineer, University of Georgia Cooperative Extension Service, Statesboro, Georgia 30460; [2]Extension Residue Chemist; [3]Extension Environmental Specialist; [4]Extension Water Quality Coordinator, Cooperative Extension Service, The University of Georgia, Athens, Georgia 30602.

REFERENCE: Proceedings of the 1995 Georgia Water Resources Conference, held April 11 and 12, 1995, at The University of Georgia, Kathryn J. Hatcher, Editor, Carl Vinson Institute of Government, The University of Georgia, Athens, Georgia.

Abstract. Beginning in 1989 the University of Georgia Cooperative Extension Service began compiling a data base to determine the extent and distribution of nitrate contamination of domestic wells in Georgia. From 1989 through 1993 3,419 wells with a known depth were sampled and analyzed for fifteen mineral elements plus pH, hardness and nitrate-nitrogen (NO_3-N). Of the shallow wells (less than 100 feet) 3.8 % had NO_3-N concentrations which exceeded EPA's action level of 10 milligrams per liter (mg/1.) Of the deep wells(100 feet or greater) 0.9 % exceeded EPA's action level.

All areas of the state were found to have some contaminated wells although the problems appear to be localized and limited mostly to shallow wells. Wells from farms where livestock or poultry were raised typically had a greater incidence of elevated nitrate levels.

INTRODUCTION

Nitrate contamination of rural domestic wells is a growing concern in Georgia as in other areas of the United States. Until the past five years, there was very little data quantifying the occurrence of nitrates in Georgia's ground water. In order to adequately manage ground water resources and prevent future contamination, it is necessary to first document the current levels of nitrate contamination and to determine the most likely sources of said contamination.

The University of Georgia Cooperative Extension Service, through its Agricultural Services Laboratories, has offered a water testing program since the early 1980's. In 1989 the University received funding from the USDA Extension Service Water Quality Initiative to test all water samples for NO_3-N and to begin building a data base to document nitrate contamination of private domestic wells. This paper is a summary of nitrate data collected from 1989 through 1993.

BACKGROUND

The adverse health effects of excessive nitrates in drinking water mainly impact infants under the age of six months.The digestive tracts of human infants contain bacteria which convert nitrate into nitrite, a toxic substance. The result is a potentially fatal condition known as methemoglobinemia or "blue baby" syndrome. Nitrates can also cause similar problems in ruminant animals such as cows and sheep and in infant monogastric animals such as pigs, horses and poultry. The EPA maximum contaminant level (MCL) for NO_3-N in drinking water is 10 mg/1.

The most common man-induced sources of nitrates in ground water are animal wastes, agricultural fertilizers, septic tanks and municipal or organic wastes. Nitrates may also originate from natural sources including nitrate bearing minerals, legumes, and natural organic decay. Natural background levels of NO_3-N, however, rarely exceed 3 mg/l.

Nitrates reach ground water primarily by leaching. Organic N or ammonia (NH_4+) sources are converted to nitrate by a process called nitrification. Because the nitrate (NO_3-) ion has a negative charge, it is not attracted to negatively charged clay particles. Thus, since nitrate is highly water soluble, any that is not utilized by plants or denitrified (converted to gas) by microorganisms can leach into ground water. Nitrates may also enter individual wells along with surface water if the well is not cased or grouted properly.

PROJECT DESCRIPTION

The Water Testing Program.

The water testing program of the University of Georgia is offered primarily as a service to private well owners to insure safe drinking water. The routine analysis includes 15 mineral elements plus pH and hardness. There is a ten dollar fee for this test. For an additional five dollar fee, the client may also choose to test for nitrates. Other tests such as volatile organics, pesticide residues, and petroleum hydrocarbons are available as needed. Biological testing for coliform bacteria is generally handled through the local health department.

Water samples are generally collected by the client in sample bottles which are available from each County receives instructions for collection of the sample and a water sample submission form. The submission form includes information about the location of the well, well depth (if known) and a description of any problems.

In 1989 the Extension Service received funding from USDA to test each sample for NO_3-N in order to build a data base on nitrate contamination. Since 1989 the Agricultural Services Laboratories have conducted between 3,000 and 5,000 routine water tests per year. Of these only about 25 % indicated well depth, which experience has shown to be a significant factor in predicting nitrate contamination. The data addressed in this paper includes all samples collected from 1989 through 1993 for which the well depth was specified on the water analysis submission form. There were a total of 3,419 such samples.

Analysis of Data.

In order to further analyze the data, the samples were separated into six major land resource areas of Georgia (Fig. 1). The actual land resource areas don't exactly follow county lines; therefore, the counties were placed in the land use area which comprised the largest portion of the county.

The three southern land resource areas (Southern Coastal Plain, Sand Hills, and Atlantic Coast Flatwoods) consist primarily of sandy or sandy loam soils overlying an extensive confined aquifer system. The aquifers in this region consist of alternating layers of sand, clay and limestone which get deeper and thicker to the Southeast.

The Southern Piedmont and Blue Ridge land resource areas consist of mostly sandy clay and clay loam soils which are underlain by massive igneous and metamorphic rocks. These rocks have a low permeability but may contain cracks and fractures which can yield usable quantities of water.

The Limestone Valley is made up primarily of a wide variety of soil types overlying sandstone, limestone, dolostone and shale of Paleozoic age. This area is characterized by a number of small aquifers none of which is laterally extensive.

The well samples were further divided into two additional

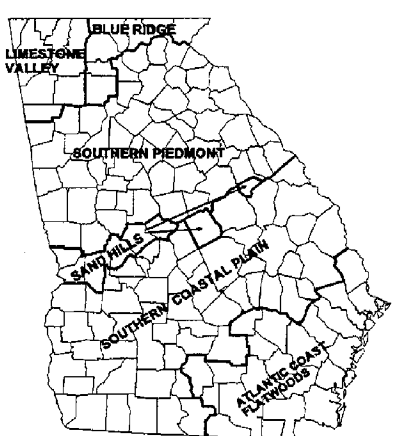

Figure 3. Major land resource areas of Georgia.

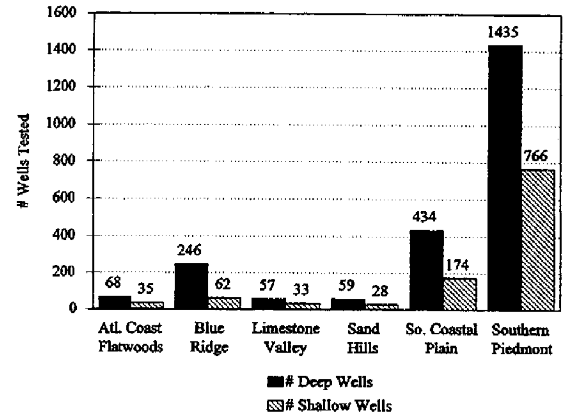

Figure 2. Number of wells tested from each of Georgia's major land resource areas.

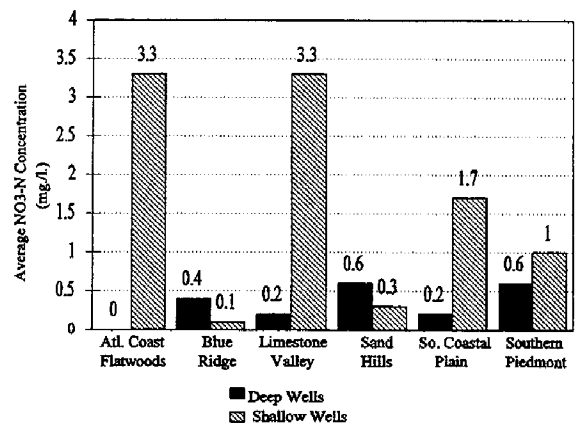

Figure 3. Average nitrate concentrations in domestic wells in Georgia by land resource area.

categories; shallow wells and deep wells. Any well less than 100 feet deep was considered a shallow well. These wells were presumed to be drawing water from the surficial, water table aquifers. All wells that were 100 feet deep or deeper were categorized as deep wells.

Figure 2 indicates the number of wells represented from each land resource area. The majority of samples were received from the Southern Piedmont and the Southern Coastal Plain. This result is logical since these are the two largest areas and the Southern Piedmont contains the highest population density of all the land resource areas.

RESULTS

Table 1 is a summary of the average nitrate levels for shallow wells and deep wells in each of Georgia's land resource areas (see also Fig. 3). Statewide, the average nitrate concentrations were 1.16 mg/1. for shallow wells and

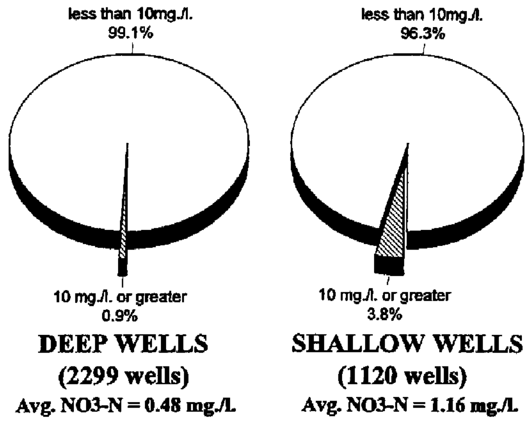

Figure 4. Results showing percentage of wells statewide which exceeded EPA's maximum contaminant level of 10 mg./l. NO3-N.

0.48 mg/1. for deep wells. The Atlantic Coast Flatwoods and the Limestone Valley had the highest average concentration of nitrates in shallow wells at 3.3 mg/1. each. It is unclear as to whether the problem is actually significantly greater in these areas or if the result could be attributed to the relatively lownumber of samples received from these areas.

Table 1 also indicates the number and percentage of wells in each area which exceeded EPA's maximum contaminant level of 10 mg./1. NO_3-N. Statewide, only 0.9 percent of deep wells and 3.8 percent of shallow wells exceeded the drinking water standard (Fig. 4).

Other Results

From 1990 through 1994 the Georgia Environmental Protection Division conducted a similar nitrate study where they sampled 2,568 wells in South Georgia and 2,241 in North Georgia. They tested only wells which were less than 250 feet deep and did not differentiate between shallow wells and deep wells. Also, their samples were collected at random, whereas ours were submitted by clientele at their own discretion. Their results indicated a slightly higher incidence of nitrates in South Georgia than in North Georgia, which might be expected because South Georgia generally has sandier soils and more agricultural activities than North Georgia. Statewide, EPD results indicated that 95% of wells had less than 5 mg/1. NO_3-N, 4 % had between 5 and 10 mg/1. and 1 % exceeded 10 mg/1. Overall, our data indicated that 1.8 percent of the wells tested exceeded 10 mg/1.

In 1994 the University of Georgia Cooperative Extension Service conducted a survey of 823 wells on farms in counties which were known to have high concentrations of livestock and poultry. Although the results have not yet been fully analyzed, they do implicate livestock and poultry operations in contributing to nitrate contamination. In this survey, 5.1 % of the wells had NO_3-N levels above 10 mg/1., and of the wells which were used specifically for livestock and poultry, 7.5 % exceeded 10 mg/1.

Table 1. Summary of NO_3-N Concentrations in Domestic Wells in Georgia, and Percent Exceeding EPA Action Level

Province	Well Type[1]	Average Well Depth (ft.)	Average NO_3-N Concentration (mg./1.)	Range of NO_3-N Concentration (mg./1.)	Number of Samples	Number ≥10 mg./l.	% of Samples Exceeding EPA Action Level[2]
Atlantic Coast Flatwoods	Shallow	39	3.3	0-35.0	35	6	17.1%
	Deep	406	0.0	0-0.2	68	0	0%
Blue Ridge	Shallow	56	0.1	0-1.7	62	0	0%
	Deep	254	0.4	0-59.0	246	2	0.8%
Limestone Valley	Shallow	58	3.3	0-90.0	33	1	3.0%
	Deep	260	0.2	0-2.1	57	0	0%
Sand Hills	Shallow	58	0.3	0-2.7	28	0	0%
	Deep	227	0.6	0-28.0	59	1	1.7%
Southern Coastal Plain	Shallow	51	1.7	0-26.3	174	13	7.5%
	Deep	262	0.2	0-16.5	434	2	0.5%
Southern Piedmont	Shallow	47	1.0	0-92.0	788	22	2.8%
	Deep	294	0.6	0-99.0	1435	16	1.1%
STATE TOTALS	Shallow	48	1.16	0-92.0	1120	42	3.8%
	Deep	284	0.48	0-99.0	2299	21	0.9%

[1]Shallow wells are defined as being less than 100 feet deep. Deep wells are defined as being 100 feet deep or greater.

CONCLUSIONS

Overall, Georgia's ground water is relatively free of nitrate contamination at the present time. There are, however, some areas of concern, specifically shallow wells and wells associated with livestock and poultry operations. Obviously more work is needed to pinpoint specific sources of nitrate contamination and to develop management practices to prevent further deterioration of well water quality in Georgia. In the meantime, much that is known regarding topics such as best management practices, nutrient management, etc. which can help prevent nitrate leaching into ground water. Educational efforts should be expanded to address these concerns.

LITERATURE CITED

Hippe, D.J., D.J. Wangsness, E.A. Frick, and J.W. Garrett. 1994. Are Farmers Contaminating the Shallow Ground Water?, Report of U.S. Geological Survey.

Kraft, George., 1994. The Extent and Sources of Nitrate Pollution in Wisconsin's Groundwater., Special Insert, Volume Z, Number 5., Central Wisconsin Groundwater Center.

O'Connell, Allison Crave, Rick Hitchcock, Bob Perkins, Parshall Bush and Sandra Chapman., 1994. Summary of Domestic Well Water Monitoring for 1993., Extension Leaflet., University of Georgia Cooperative Extension Service.

Shellenberger, Don and Bob Barget., 1994. Assessment of Nitrate Levels in Georgia's Ground Water., Unpublished Summary Report., Georgia Department of Natural Resources.

Tyson, A.W., 1993. Georgia's Ground Water Resources., Bulletin 1096. University of Georgia Cooperative Extension Service.